WHAT IS CLAIMED IS:

1. A ball mill, comprising:

a tubular vessel for containing grinding media and a material to be ground, the tubular vessel having an axis; and

a drive mechanism that induces a linear reciprocating movement of the tubular vessel substantially along the axis of the vessel to grind the contained material by moving the grinding media back and forth within the tubular vessel.

2. The ball mill as in claim 1 wherein the linear reciprocating movement occurs at a rate in excess of 1000 cycles per second.

3. The ball mill as in claim 1 wherein the linear reciprocating movement produces a stroke distance in excess of 1 inch.

4. The ball mill as in claim 1 wherein the axis of the tubular vessel is substantially vertically oriented.

5. The ball mill as in claim 1 wherein the axis of the tubular vessel is substantially horizontally oriented.

6. The ball mill as in claim 1 wherein the grinding media comprises a single ball having a diameter that is less than an inner diameter of the tubular vessel.

7. The ball mill as in claim 6 wherein ends of the tubular vessel are defined by a spherical surface conforming to the inner diameter of the capped tubular vessel.

8. The ball mill as in claim 7 wherein the spherical surface is hemispherical.

9. The ball mill as in claim 1 wherein the grinding media comprises a plurality of balls.

10. The ball mill as in claim 9 wherein the plurality of balls are of differing sizes.

11. The ball mill as in claim 1 wherein the grinding media comprises a single cylindrical slug having a diameter that is less than an inner diameter of the tubular vessel.

12. The ball mill as in claim 11 wherein ends of the tubular vessel are defined by a flat surface.

13. The ball mill as in claim 11 wherein ends of the tubular vessel are defined by a conical surface.

14. The ball mill as in claim 1 further including:

a platform supporting the tubular vessel; and

a drive rod transferring the induced linear reciprocating movement to the platform supporting the tubular vessel.

15. The ball mill as in claim 14 further including an air bearing supporting substantially frictionless movement of the drive rod.

16. The ball mill as in claim 1 the axis of the tubular vessel is offset from a direction of the induced linear reciprocation by an acute angle.

17. A ball mill, comprising:

a sample holder comprised of a plurality of vessels, each vessel having a tubular configuration and a longitudinal axis about which an interior for performing ball grinding is defined; and

means for reciprocating the sample holder in a direction substantially parallel to axes of the plurality of vessels within the sample holder.

18. The ball mill as in claim 17 wherein the means for reciprocating comprises a vertically reciprocating drive mechanism having a drive rod that induces reciprocating movement of the sample holder substantially along the longitudinal axes of the vessels.

19. The ball mill as in claim 17 wherein the means for reciprocating comprises a horizontally reciprocating drive mechanism having a drive rod that induces reciprocating movement of the sample holder substantially along the longitudinal axes of the vessels.

20. The ball mill as in claim 17 further including a dampening base.

21. A ball mill vessel, comprising:

a cylinder having a longitudinal axis and a bore extending from a first end of the cylinder along the longitudinal axis and terminating prior to a second end of the cylinder to form an integral cap at the second end; and

a cap including an insert portion sized and shaped for insertion into the bore at the first end of the cylinder.

22. The ball mill vessel as in claim 21 wherein the bore terminates prior to the second end to form a spherical surface and the insert portion of the cap includes a spherical recess.

23. The ball mill vessel as in claim 22 wherein the bore has a radius and the spherical surface and spherical recess are defined by a substantially identical radius.

24. The ball mill vessel as in claim 22 wherein the spherical surface and spherical recess are hemispherical in shape.

25. The ball mill vessel as in claim 21 further including a single grinding ball within the bore.

26. The ball mill vessel as in claim 25 wherein a radius of the single grinding ball is slightly smaller than a radius of the bore.

27. The ball mill vessel as in claim 21 further including a plurality of grinding balls within the bore.

28. The ball mill vessel as in claim 21 further including a single cylindrical slug within the bore.

29. The ball mill vessel as in claim 21 wherein the vessel has a hollow circular cross-section.

30. A ball mill vessel, comprising:

a tube having a longitudinal axis and an opening extending from a first end of the tube to a second end of the tube; and

a first cap to cover the first end of the tube; and

a second cap to cover the second end of the tube.

31. The ball mill vessel as in claim 30 wherein the first and second cap include a spherical recess.

32. The ball mill vessel as in claim 31 wherein the opening for the tube is defined by a radius and the spherical recesses are each defined by a substantially identical radius.

33. A ball mill grinding method, comprising the steps of:

loading a vessel with a grinding media and a material to be ground, the vessel having a longitudinal axis;

capping the vessel to contain the grinding media and material; and

reciprocating the capped vessel containing the grinding media and material to be ground in a direction substantially along the longitudinal axis.

34. The ball mill grinding method as in claim 33 wherein the step of reciprocating comprises the step of reciprocating with a vertical orientation.

35. The ball mill grinding method as in claim 33 wherein the step of reciprocating comprises the step of reciprocating with a horizontal orientation.

36. The ball mill grinding method as in claim 33 wherein the step of loading comprises the step of loading a single ball within the vessel.

37. The ball mill grinding method as in claim 33 wherein the step of loading comprises the step of loading a plurality of balls within the vessel.

38. The ball mill grinding method as in claim 37 wherein the plurality of balls are of differing sizes.

39. The ball mill grinding method as in claim 33 wherein the step of loading comprises the step of loading a single cylindrical slug within the vessel.